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EXPERIMENTAL STUDY OF COMBINED NEAR-FIELD INTERACTIONS AND FAR-FIELD EFFECTS OF WAVE ENERGY CONVERTER FARMS: DEVELOPMENT OF A SINGLE ENERGY DEVICE

Introduction

To make wave energy converters (WECs) economically attractive as an alternative energy source, the levelized cost of energy (LCOE) needs to be competitive with other renewable energy sources. Increasing the power output can be achieved by placing a large number of WECs at the same site in an array geometrical layout, which is called a WEC farm. Since an efficient wave absorber is also an efficient wave generator, one can theoretically benefit from placing the WECs in a well-considered geometrical layout.

Scientific background

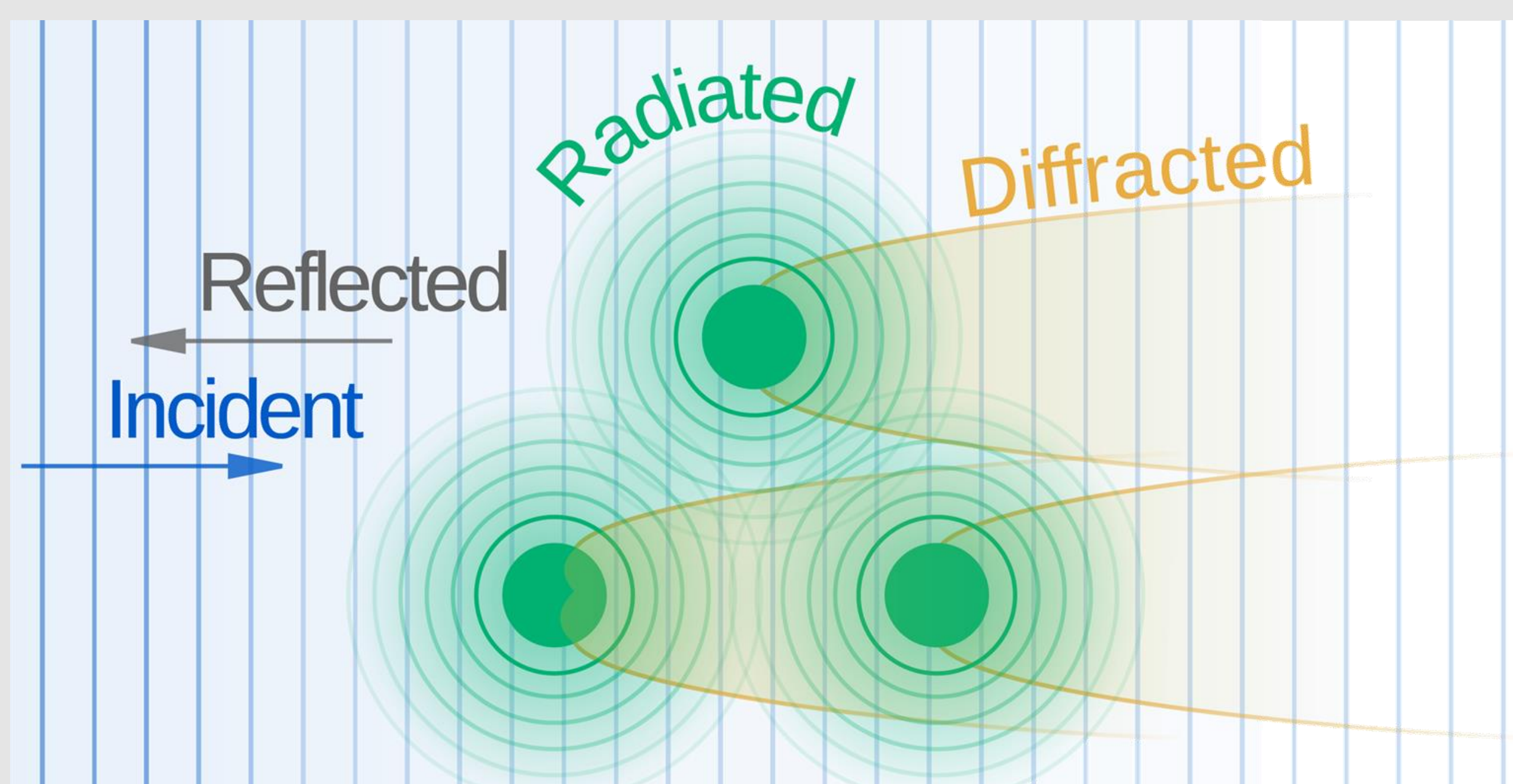


Fig. 1: Visual representation of incident, reflected, radiated and diffracted waves around an array of three floating structures. The combination results in the total wave field. [2]

WECs placed in a farm are responsible for the occurrence of two general phenomena: near-field interactions between the WECs, and far-field effects of the WEC farm on the surrounding wave field, illustrated in Fig. 1.

The motion of a single WEC will positively or negatively affect the power absorption of neighbouring WECs. These near-field interactions are dependent on the incoming wave conditions, the WEC farm layout and the WEC inter-distance. On the other hand, the power absorption of the entire WEC farm reduces the wave height behind the farm. The possible influence of WEC farms on neighbouring farms, offshore activities, marine ecology and the coastline is expressed by the far-field effects.

In the framework of the EU Hydralab IV 'WECwakes' project coordinated by Ghent University (UGent), the above phenomena have been investigated for an experimental layout of up to 25 heaving WECs, illustrated in Fig. 2 [1]. The obtained unique database served for validation purposes of numerical models, such as for numerical coupling methodologies for studying wave-WEC interactions (near-field effects) and wave propagation through WEC farms (far-field effects) [2].



Fig. 2: Experimental array set-up of the 'WECwakes' project. [1]

Research objectives

However, since the completion of the 'WECwakes' project, many numerical models have progressively advanced. To allow validating these new advanced models, the new 'WECfarm' project has been introduced by UGent and its partners.

References

- [1] Stratigaki, V., 2014. "Experimental study and numerical modelling of intra-array interactions and extra-array effects of wave energy converter arrays", PhD Thesis, Ghent University. Ghent, Belgium
- [2] Verbrughe, T., 2018. "Coupling Methodologies for Numerical Modelling of Floating Wave Energy Converters", PhD Thesis, Ghent university. Ghent, Belgium

Main objective is to experimentally investigate near-field interactions and far-field effects for different WEC farm layouts and WEC inter-distances. These tests aim to cover the gap of available experimental data which can be used for validation of recently developed (non-linear) numerical models. As such, the new WEC farms will be also tested under (extreme) wave conditions that induce non-linear effects.

Experiments with WEC farms will be conducted in the Coastal and Ocean Basin (COB) (see Fig. 3) in Ostend in 2020, while in 2019 a single 'Master WEC' will be developed, tested and fine-tuned prior to the 'WECfarm' tests.

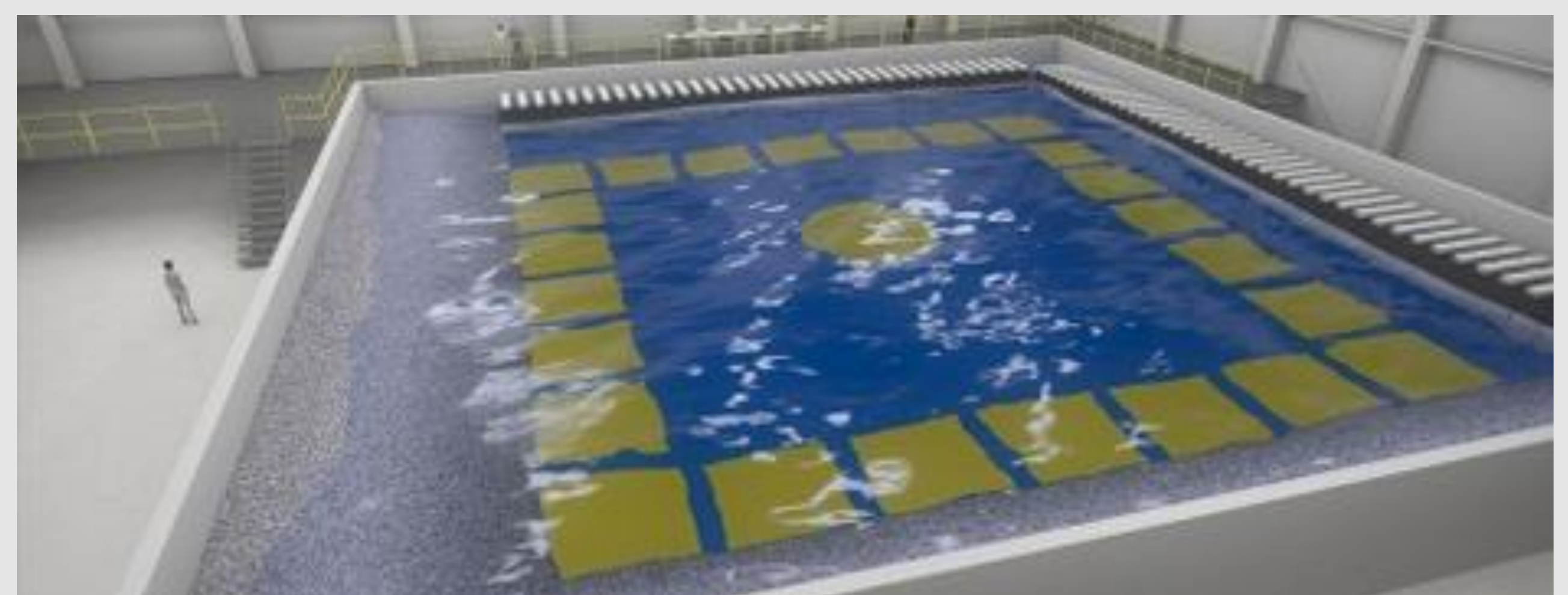


Fig. 3: Artist impression of the Coastal and Ocean Basin (COB)

Methodology

Fig. 4 shows a sketch of the design of the 'Master WEC'. The hydrodynamic part of the design constitutes the floating buoy. Regarding the geometry, a cylindrical float is designed with a relative large diameter compared to the draft, which aims at maximizing wave radiation and thus inducing positive near-field interactions. The small draft is to limit the surge force, since the WEC will operate according to the heave mode only.

The mechanical part of the WEC design constitutes:

- the power take-off (PTO) for which a rack and pinion system is chosen.
- air bushings to exclude friction effects in the power absorption measurements. A permanent layer of pressurized air between the interface of the bushing's guide with the exterior frame results in a situation where the contribution of friction to the total power absorption is negligible.

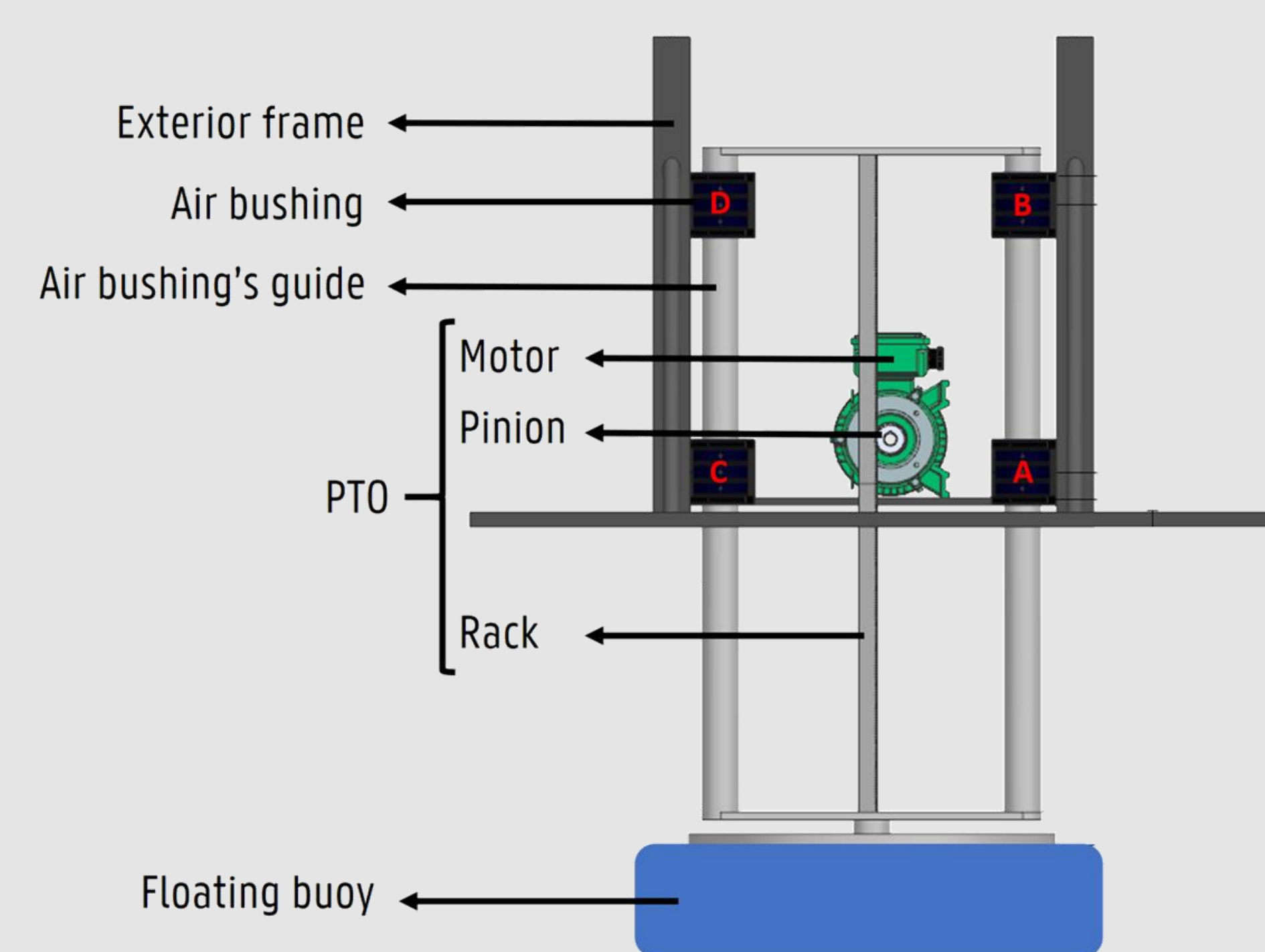


Fig. 4: Sketch of the design of the 'Master WEC'

The constructed 'Master WEC' is a first step towards the final objectives of the 'WECfarm' project.

Acknowledgements

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